

**Naval Health Research Center
Environmental Health Effects Laboratory**

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**DERIVATION OF NAVY OCCUPATIONAL EXPOSURE LIMITS (OELS)
FOR TWO SOLVENT COMPOUNDS: VERTREL MCA AND HFE-71DE**

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Abstract:

Currently, the US Navy uses the solvent HFC-141b to clean hydraulic gauges in a semi-closed system prior to gauge calibration. The US Navy will not be able to use the solvent HFC-141b after 31 December, 2002, because of a ban on its manufacture. The Navy is considering both Vertrel MCA and HFE-71DE as replacements for HFC-141b. Both solvents are azeotropic mixtures consisting of trans 1,2-DCE and either fluorocarbons or ethers. Both Vertrel MCA and HFE-71DE have high vapor pressures, therefore, they are expected to volatilize at room temperature. The potential routes of exposure to solvent during the gauge cleaning process are inhalation of vapors and dermal contact with liquid when pouring new and spent solvents into flasks and containers. At this time, toxicity information is not available for the azeotropic mixtures Vertrel MCA and HFE-71DE. It was decided that the human NOEL data for trans 1,2-DCE is the most appropriate toxicity data for deriving OEL's for Vertrel MCA and HFE-71DE. OEL's were derived using procedures recommended by the National Research Council. The NOEL of 800 ppm trans 1,2-DCE in air for an exposure time of 30 minutes was used as the endpoint for deriving 5, 10, 30, 60, 90, 120, 240, and 480-minute OEL's for Vertrel MCA and HFE-71DE. The derived OEL's for Vertrel MCA and HFE-71DE range between 48 for 5 minute exposures to 0.5 ppm for 8 hour exposures. The derived OEL's for Vertrel MCA and HFE-71DE are lower than the 8-hour TLV-TWA for trans 1,2-DCE of 200 ppm, but the conservative nature of the recommended OEL's reflect the lack of toxicity information for Vertrel MCA and HFE-71DE and their major ingredients. Naval Health Research Center/Toxicology endorses the use of personal protective equipment when handling or using these chemicals as recommended by Naval Environmental Health Center industrial hygienists.

Background:

Naval Health Research Center/Toxicology (NHRC/TD) was asked by Naval Environmental Health Center (NEHC) to review the exposure scenario for two proposed solvents to be used for cleaning gauges and determine whether exposure limits promulgated by the manufacturers for these solvents are appropriate. Currently, the Navy's calibration laboratories use the solvent HCFC-141b to clean hydraulic gauges prior to calibration. HCFC-141b will not be manufactured after 31 December, 2002. Two solvents being considered as replacements for HCFC-141b are Vertrel MCA and HFE-71DE. Both substances are azeotropic mixtures containing 1,2-trans-DCE. Vertrel MCA also contains HFC-43-10mee (59%). HFE-71DE contains 49-51% methyl nonafluoroisobutyl ether/methyl nonafluorobutyl ether. Both solvents have relatively high vapor pressures at room temperature (25°C) indicating that these substances will volatilize to some extent and enter the air if used in "open" cleaning systems (e.g., the vapors are not trapped or prevented from entering the air by engineering controls).

According to the information sent to NHRC/TD (Bishop 2002), the proposed solvents will be used in a semi-closed cleaning system. Hydraulic gauges are connected to a vacuum pump and solvent is drawn into the gauge through a rubber hose from an Erlenmeyer flask containing "clean" solvent. "Spent" solvent is then drawn out of the gauge through a rubber hose and into a second Erlenmeyer flask. This process is repeated until the gauge is considered clean. The gauge cleaning system is recharged by pouring clean solvent into the first Erlenmeyer flask and pouring out the spent solvent in the second Erlenmeyer flask into a waste solvent container. The maximum amount of solvent used per gauge is 500 ml, but may be considerably less than this amount. The steps in the cleaning procedure with the greatest potential for solvent exposure are those that involve pouring new and spent solvents to and from flasks and containers. Some labs devote an hour per day to cleaning gauges, while other labs spend up to half a day per week. However, it was not indicated how many times the cleaning process is repeated in these labs per day or per week.

Administrative health hazard assessments of Vertrel MCA and HFE-71DE have been conducted by NEHC (NEHC 2002a,b). These assessments included review of manufacture MSDS's for Vertrel MCA and HFE-71DE and a check to see if the chemicals were listed in the IARC Monographs, OSHA Regulated Carcinogen/Toxic Hazard Substance list, the NTP Ninth Annual Report on Carcinogens, and several Code of Federal Regulations and Navy instructions. Neither compound was found to be listed as a potential carcinogen in any of the named sources. In both cases, it was concluded by the NEHC Industrial Hygiene Directorate that the use of these chemicals may present a significant health hazard for personnel and persons working in the vicinity of the cleaning operation, but Vertrel MCA and HFE-71DE could be safely used for the intended purpose provided that precautions outlined in the health hazard assessments are strictly followed. Each assessment provides a detailed set of precautions for use of the chemicals and personal protective equipment that should be worn by persons with potential exposure to Vertrel MCA or HFE-71DE. Potential routes of solvent exposure identified in these assessments were dermal contact with the solvent, inhalation of solvent vapors, and accidental ingestion.

Manufacturer-Recommended Exposure Limits:

Exposure limits for Vertrel MCA and HFE-71DE are not given in their MSDS sheets. However, the MSDS's for these compounds list OSHA- and ACGIH-recommended exposure limits for their component materials. The MSDS's for Vertrel MCA and HFE-71DE list both the OSHA-recommended Permissible Exposure Limit (PEL) and the ACGIH-recommended Threshold Limit Value- Time-Weighted Average (TLV-TWA) for trans 1,2-DCE of 200 ppm (790 mg/m³). These exposure limits are based on toxic effects in the liver (ACGIH 2002).

Vertrel MCA consists of trans 1,2-DCE (59-65%) and HFC-43-10mee (35-41%). Neither OSHA nor ACGIH have developed exposure limits for HFC-43-10mee. The MSDS for Vertrel MCA indicates that DuPont Chemical recommends an Acceptable Exposure Limit (AEL) of 200 ppm (8 & 12 hour Time-Weighted Average) and a 400 ppm Ceiling exposure limit for HFC-43-10mee. The basis for this exposure limit is not indicated in the MSDS.

HFE-71DE consists of trans 1,2-DCE (49-51%) and methyl nonafluoroisobutyl ether/methyl nonafluorobutyl ether (49-51%). The MSDS for HFE-71DE indicates that the AIHA has developed a Workplace Environmental Exposure Level (WEEL) for methyl nonafluoroisobutyl ether and methyl nonafluorobutyl ether of 750 ppm. The basis for this exposure limit is not indicated in the MSDS.

No manufacturer-recommended exposure limits or reference doses are given for the oral or dermal routes of exposure in the MSDS documents for Vertrel MCA and HFE-71DE.

NHRC/TD Recommendations:

According to the description of the gauge cleaning process provided to NHRC/TD, it appears that the main routes for potential solvent exposure of Navy personnel are inhalation of solvent vapors and dermal contact. Inhalation of solvent vapors is most likely to occur when adding clean solvent and removing waste solvent from the gauge cleaning system. Volatilization and escape of solvent vapors during actual gauge cleaning is a possibility, but the concentration of vapors produced in air is probably small based on the description of the gauge cleaning system. Wear of PPE recommended by NEHC (NEHC 2002a,b) would significantly reduce or eliminate solvent exposure from the dermal and inhalation exposure pathways.

There have been no exposure limits promulgated for either Vertrel MCA or HFE-71DE by the manufacturers or by regulatory or scientific groups (e.g., OSHA, NIOSH, ACGIH, AIHA, etc). As mentioned in the manufacture MSDS's for Vertrel MCA and HFE-71DE, both products are azeotropic mixtures containing trans 1,2-DCE and fluorocarbons or ethers. Therefore, vapors of these products will contain all components at the ratios that are listed for their liquid forms. Since there are no exposure limits or toxicity data available for Vertrel MCA or HFE-71DE, it is the opinion of NHRC/TD that occupational exposure limits for these products should be developed using the most appropriate toxicity data available for the component materials of Vertrel MCA and HFE-71DE. Occupational Exposure Limits (OEL's) for Vertrel MCA and HFE-71DE should be calculated by dividing the most relevant No Observed Effect Level

(NOEL) by appropriate uncertainty factors (UF's) following National Research Council (NRC) guidelines for calculating Acute Exposure Guideline Levels (AEGL's) for hazardous chemicals (NRC 2001).

Vertrel MCA

Vertrel MCA is an azeotropic mixture of trans 1,2-DCE (59-65%) and HFC-43-10mee (35-41%). The OSHA-recommended Permissible Exposure Limit (PEL) and the ACGIH-recommended Threshold Limit Value- Time-Weighted Average (TLV-TWA) for trans 1,2-DCE is 200 ppm (790 mg/m³) for an 8-hour work day. The NIOSH Pocket Guide (NIOSH 1994) lists the Immediately Dangerous to Life or Health (IDLH) exposure limit for 1,2-DCE as 1,000 ppm and is based on acute effects observed in humans. OSHA has not promulgated an exposure limit for HFC-43-10mee.

There is limited human toxicity data available for trans 1,2-DCE. Exposure to trans 1,2-DCE at 2,200 ppm was shown to cause burning of the eyes, vertigo, and nausea (von Oettingen 1955). Exposure to trans 1,2-DCE at a concentration of 819 ppm in air for 30 minutes did not result in any reportable effects in humans (von Oettingen 1955). Inhalation of 1,687 to 2,184 ppm trans 1,2-DCE for 5 minutes or 1,191 ppm for 10 minutes resulted in vertigo, pressure in the head, and somnolence (von Oettingen 1937). Prolonged contact of the skin and eyes with 1,2-DCE is associated with irritation and dermatitis (Sittig 1985).

Inhalation LC50s for trans 1,2-DCE in rodents range from 21,723 - 24,100 ppm while the oral LD50 for trans 1,2-DCE in rodents range from 1,235-2,122 mg/kg (HSDB 2002). We did not locate any information on the dermal doses of trans 1,2-DCE that cause lethality or internal organ injury. Trans 1,2-DCE is not listed as a carcinogen by USEPA or IARC, however, there are no published studies to date that we are aware of that have investigated the carcinogenicity of this compound in rodents or humans. Trans 1,2-DCE was not mutagenic when tested in various *in vitro* genotoxicity test systems (HSDB 2002, NTP 2002). No increase in sister chromatid exchanges or chromosomal aberrations in bone marrow cells were found for male mice given trans 1,2-DCE by intraperitoneal injection (NTP 2002). Negative results were also obtained in a peripheral blood micronucleus test in male and female mice administered trans 1,2-DCE in microcapsules in their food for 14 weeks (NTP 2002).

There is no human data available on the toxicity of HFC-43-10mee. No published studies were located on the toxicity of HFC-43-10mee in laboratory animals. The MSDS for Vertrel MCA indicates that HFC-43-10mee is a slight skin irritant and a mild eye irritant, but is not a skin sensitizer in laboratory animals. A one-time exposure of rats to 5,000 ppm HFC-43-10mee in air caused tremors, decreased coordination, hyperactivity and prostration. However, the length of time that the rats were exposed to HFC-43-10mee was not indicated. Kidney and lung changes were observed along with external hair loss.

Repeat exposure of rats to 1,900 - 3,500 ppm HFC-43-10mee was shown to cause temporary tremors, convulsions, behavioral, and altered clinical chemistry effects. Again, the length of time that the rats were exposed to HFC-43-10mee per exposure was not indicated. The

No-Observed-Adverse-Effect-Level (NOAEL) for convulsions in rats exposed to HFC-43-10mee was 1,000 ppm. DuPont Chemical reports that the 90-day No-Observed-Adverse-Effect-Level (NOAEL) for toxic effects of HFC-43-10mee in rats is 500 ppm. No animal data are available on the carcinogenicity or reproductive toxicity of HFC-43-10mee. DuPont Chemical reports that tests have shown that HFC-43-10mee does not cause genetic damage in bacterial or mammalian cell cultures or in tests in laboratory animals.

Vertrel MCA Occupational Exposure Level (OEL) Recommendation

As noted previously, there is no promulgated occupational exposure limit for Vertrel MCA and there is no toxicity data available for Vertrel MCA for deriving OEL's. Inhalation of Vertrel MCA vapors appears to be the primary route of concern for human exposure to Vertrel MCA for persons involved in cleaning gauges. Vertrel MCA vapors are expected to consist of trans 1,2-DCE and HFC-43-10mee at a ratio of approximately 40:60. There is some human toxicity information for trans 1,2-DCE; none for HFC-43-10mee. The No Observed Effects Level (NOEL) for trans 1,2-DCE is reported to be 800 ppm for a 30 minute exposure based on the absence of neurological symptoms observed in humans at higher trans 1,2-DCE concentration levels in air. NOEL's for adverse neurologic effects in rats are reported as 500 ppm for a single inhalation exposure and 1,000 ppm for multiple inhalation exposures. The amount of time that rats were exposed to HFC-43-10mee during each exposure segment is not reported by Dupont Chemical in the MSDS for Vertrel MCA.

It was decided that the NOEL for trans 1,2-DCE is the most relevant endpoint for deriving OEL's for Vertrel MCA. The basis for this decision is the lack of information on the toxicity of HFC-43-10mee in humans and inadequate information on the exposure regimens used to determine rat NOEL's for HFC-43-10mee inhalation exposures. Exposure duration-specific OEL's were derived for Vertrel MCA according to guidelines set forth for calculating Acute Exposure Guideline Levels (AEGL's) by the National Research Council (NRC 2001). The NOEL of 800 ppm for exposure duration of 30 minutes was used as the point of departure for calculating OEL's for Vertrel MCA. A total uncertainty factor of 30 was applied to the NOEL for Vertrel MCA following the AEGL guidelines developed by NRC (2001) ($800 \text{ ppm}/27 \approx 30 \text{ ppm}$). The total uncertainty factor applied consists of: 1) an uncertainty factor of 3 to account for uncertainty regarding chronic health effects associated with repeat exposure to Vertrel MCA; 2) a factor of 3 to adjust the NOEL to protect against toxicity in persons particularly sensitive to Vertrel MCA exposure; and 3) a factor of 3 to account for the fact that no toxicity information is available for Vertrel MCA but some toxicity information is available for its component chemicals.

OEL's were derived from the 30 minute NOEL for trans 1,2-DCE using the equation $C^n \cdot t = k$ where C is the derived NOEL (e.g., NOEL multiplied by the uncertainty factor of 30), t is the NOEL exposure duration, and n = 1 as recommended by NRC (2001). Given that the derived 30 minute NOEL for 1,2-DCE is 30 ppm, the constant k would be calculated using the following equation:

$$C^n \bullet t = k$$

$$k = [30]^1 \text{ ppm} \bullet 30 \text{ minutes}$$

$$k = 900 \text{ ppm} \bullet \text{minutes}$$

Thus, the 5 minute OEL for Vertrel MCA is 180.0 ppm. OEL's calculated for exposure durations of 10, 30, 60, 90, 120, 240, and 480 minutes are listed in Table 1.

Table 1: OEL's recommended for Vertrel MCA based on NOEL toxicity data for trans 1,2-DCE	
Exposure duration (minutes)	Recommended OEL (ppm)
5	180.0
10	90.0
30	30.0
60	15.0
90	10.0
120	7.5
240	3.8
480	1.9

HFE-71DE

HFE-71DE is an azeotropic mixture of trans 1,2-DCE ($\approx 50\%$) and methyl nonafluoroisobutyl ether/methyl nonafluorobutyl ether ($\approx 50\%$). The OSHA-recommended Permissible Exposure Limit (PEL) and the ACGIH-recommended Threshold Limit Value- Time-Weighted Average (TLV-TWA) for trans 1,2-DCE is 200 ppm (790 mg/m^3) for an 8-hour work day. OSHA has not promulgated an exposure limit for methyl nonafluoroisobutyl ether/methyl nonafluorobutyl ether. AIHA recommends a Workplace Environmental Exposure Level (WEEL) for methyl nonafluoroisobutyl ether and methyl nonafluorobutyl ether of 750 ppm.

The toxicity of trans 1,2-DCE was discussed previously in the section on deriving OEL's for Vertrel MCA. No information was found regarding the toxicity of methyl nonafluoroisobutyl ether or methyl nonafluorobutyl in humans. Several sources of toxicity information were consulted for information on these chemicals including Patty's Industrial Hygiene, Sax's Dangerous Properties of Industrial Materials, IRIS, the HSDB, TOXLINE, and PUBMED.

There is considerable animal toxicity data available for methyl nonafluoroisobutyl ether/methyl nonafluorobutyl ether (40:60 percent ratio) as reported by AIHA (1999). Methyl nonafluoroisobutyl ether/methyl nonafluorobutyl ether (40:60 percent ratio), also referred to as HFE 7100, is minimally irritating to the skin of rabbits after a single application and does not elicit dermal sensitization in guinea pigs. Metabolites of HFE 7100 were not found in the blood of rabbits given dermal applications of HFE 7100 at a dose level of 15 mg/kg/d for 5 consecutive days. Blood samples were collected for analysis on days 1-10 and day 29 of the study. No deaths occurred in rats exposed to 100,000 ppm HFE 7100 in air for 4 hours. No evidence of cardiac sensitization was observed for Beagle dogs exposed to 10,000 – 100,000 ppm HFE 7100 in air for 5 minutes. Clinical signs of toxicity were observed (restlessness, limb rigidity, tremors) in Beagle dogs exposed to 50,000 ppm or 100,000 ppm HFE 7100 for 5 minutes.

HFE 7100 was not found to be mutagenic in the Ames test with or without exogenous metabolic activation and did not cause chromosomal aberrations in Chinese hamster ovary cells. HFE 7100 exposure did not cause an increase in bone micronuclei in mice administered up to 5,000 mg/kg (AIHA 1999).

HFE 7100 is not considered a teratogenic compound based on studies reported by AIHA (1999). The number of fetuses with supernumerary ribs was found to be greater for pregnant female rats exposed to 30,000 ppm HFE 7100 in air 6/hr/d for days 6-19 of gestation as compared with negative controls. However, it was concluded that the increase in this anomaly was a secondary effect associated with maternal stress and not a direct effect of the chemical on fetal development. The NOEL for developmental effects in these studies was reported to be 7,500 ppm HFE 7100 in air.

Reversible liver changes were identified in rats exposed daily to HFE 7100 by oral gavage for 28 days (AIHA 1999). HFE 7100 was administered by oral gavage to groups of adult rats at 9, 40, 200, and 1,000 mg/kg/d for 28 days. Males in the high dose group have increased liver and thyroid weights at the end of the study. Histopathology examination revealed hypertrophy of the centrilobular hepatocytes and follicular cells of the thyroid. Serum albumin levels were also increased in the males of the high dose group. The described changes were not present in high dose animals 2 weeks after dosing was ended on Day 28 of the dosing period. It was concluded that the observed liver effects were reversible changes. No treatment-related effects were identified in high dose females. No treatment-related changes were identified in animals administered 9, 40, or 200 mg/kg/d HFE 7100 for 28 days.

Evidence of liver peroxisome proliferation was identified in male rats exposed to 28,881 ppm HFE 7100 for 6 hours/day, 5 days/week for 28 days (AIHA 1999). Rats were exposed to 0, 1,489, 2,935, 9,283, or 28,881 ppm HFE 7100 for 6 hours/day, 5 days/week for 28 days. Increased liver weights and increases in palmitoyl CoA oxidase activity were observed in male animals exposed to 28,881 ppm HFE 7100. Hypertrophy of the centrilobular hepatocytes was detected in 3 of 10 rats exposed to 9,283 ppm and 9 of 10 rats exposed to 28,881 ppm HFE 7100. No other treatment-related effects were observed in HFE 7100-exposed animals.

Evidence of liver peroxisome proliferation was identified in both male and female rats exposed to 15,000 ppm HFE 7100 for 6 hours/day, 5 days/week for 90 days (AIHA 1999). Rats were exposed to 0, 1,500, 4,500, 7,500, or 15,000 ppm HFE 7100 for 6 hours/day, 5 days/week for 90 days. Increased liver, spleen, and kidney weights and increases in palmitoyl CoA oxidase activity found in male animals exposed to 15,000 ppm HFE 7100. Minor hypertrophy of the centrilobular hepatocytes was detected in male and female rats exposed to 15,000 ppm HFE 7100. No evidence of neurotoxicity was found for rats exposed to 15,000 ppm HFE 7100 when assessed using the functional observation battery.

Citing a 1997 internal correspondence from 3M, AIHA (1999) notes that no adverse health effects have been reported from workers using HFE 7100 as a solvent where concentrations of HFE 7100 in air were generally less than 50 ppm when samples were taken near vapor degreasers.

HFE-71DE Occupational Exposure Level (OEL) Recommendation:

There are no promulgated occupational exposure limits for the azeotropic mixture HFE-71DE and no toxicity information is available for the azeotropic mixture HFE-71DE that could be used for deriving occupational exposure limits. There is toxicity information available for trans 1,2-DCE, a major component of HFE-71DE; the inhalation NOEL for trans 1,2-DCE for humans is approximately 800 ppm for an exposure period of 30 minutes. There is information on the acute, sub-acute, sub-chronic, chronic, and developmental toxicity of HFE 7100 in animals as summarized by AIHA (1999). We believe that much of this information has been published in peer-reviewed scientific journals. AIHA (1999) cites and summarizes an internal correspondence from 3M with anecdotal information that no adverse health effects have been reported from workers involved in degreasing work using HFE 7100.

After carefully considering all available toxicity information for HFE-71DE and its component materials, it was decided that the human NOEL for trans 1,2-DCE is the most appropriate endpoint for deriving OELs for HFE-71DE. Exposure duration-specific OELs for HFE-71DE were calculated according to guidelines set forth for calculating Acute Exposure Guideline Levels (AEGs) by the National Research Council (NRC 2001). The NOEL of 800 ppm for exposure duration of 30 minutes was used as the endpoint for calculating OELs for HFE-71DE. A total uncertainty factor of 100 was applied to the trans 1,2-DCE NOEL concentration of 800 ppm following the guidelines developed by NRC (2001) ($800 \text{ ppm}/100 \approx 8 \text{ ppm}$). An uncertainty factor of 10 was applied to the NOEL to account for uncertainty regarding chronic health effects associated with repeat exposure to HFE-71DE. A second uncertainty factor of 3 was applied to the NOEL to provide protection against toxicity among individuals in the human population that could be particularly sensitive to HFE-71DE exposure. A third uncertainty factor of 3 was applied to the NOEL to account for the fact that no toxicity information is available for the azeotropic mixture HFE-71DE, but there is a moderate amount of information on the toxicity of its component materials.

OELs were derived from the 30 minute NOEL for trans 1,2-DCE using the equation $C^n \cdot t = k$ where C is the derived NOEL (e.g., NOEL divided by the uncertainty factor of 100), t is the NOEL exposure duration, and $n = 1$ as recommended by NRC (2001) for extrapolating NOEL concentrations for exposure durations of 5, 10, 60, 90, 120, 240, and 480 minutes as recommended by NRC (2001). Given that the derived 30 minute NOEL for HFE-71DE is 800 ppm, the constant k would be calculated using the following equation:

$$C^n \cdot t = k$$

$$k = [8]^1 \text{ ppm} \cdot 30 \text{ minutes}$$

$$k = 240 \text{ ppm} \cdot \text{minutes}$$

Thus, the 5 minute OEL for HFE-71DE is 180.0 ppm. OELs calculated for exposure durations of 10, 30, 60, 90, 120, 240, and 480 minutes are listed in Table 2.

Table 2: OELs recommended for HFE-71DE based on NOEL toxicity data for trans 1,2-DCE	
Exposure duration (minutes)	Recommended OEL (ppm)
5	48
10	24
30	8
60	4
90	3
120	2
240	1
480	0.5

Summary:

Currently, the US Navy uses the solvent HFC-141b to clean hydraulic gauges prior to calibration. These gauges are cleaned in a semi-closed system whereby the clean solvent in an Erlenmeyer flask is forced into the gauge to be cleaned via a hose by application of a vacuum. Once the gauge is cleaned, the spent solvent is discarded from the gauge through a hose into an Erlenmeyer flask. The system is recharged by pouring new solvent from a storage container into the first Erlenmeyer flask and the spent solvent in the second flask is poured into a waste container. The total amount of HFC-141b used in this routine is not more than 500 ml per gauge. Based on the description of current operations sent to NEHC, it appears that laboratories involved in this process can process several gauges in a day. The potential routes of exposure to solvent during the gauge cleaning process appear to be inhalation of solvent vapors and dermal contact with solvent during the pouring of new and spent solvents into flasks and containers.

The US Navy will not be able to use the solvent HFC-141b after 31 December, 2002, because of a ban on its manufacture. The Navy is considering both Vertrel MCA and HFE-71DE as replacements for HFC-141b. Both solvents are azeotropic mixtures consisting of trans 1,2-DCE and either fluorocarbons or ethers. Both Vertrel MCA and HFE-71DE have high vapor pressures, therefore, they are expected to volatilize at room temperature. Since Vertrel MCA and HFE-71DE are azeotropic mixtures, vapors of Vertrel MCA and HFE-71DE will consist of trans 1,2-DCE and either fluorocarbons or ethers in proportions approximately equal to those as described for their liquid forms (e.g., 40:60 and 50:50). Toxicity information is not available for either Vertrel MCA or HFE-71DE. There is some toxicity information for the major ingredient trans 1,2-DCE. Exposure of humans to 819 ppm of trans 1,2-DCE in air for 30 minutes did not cause any symptoms of toxicity whereas exposure to higher concentrations (1,191 - 2,184 ppm) resulted in vertigo, pressure in the head, and somnolence in human volunteers. Trans 1,2-DCE is not mutagenic or genotoxic and is not listed as a carcinogen by USEPA or IARC. However, there are no published studies on trans 1,2-DCE indicating that this chemical is not carcinogenic to laboratory animals or humans.

There is limited toxicity information on HFC-143-10mee, the second ingredient in Vertrel MCA, and HFE 7100, the second ingredient of HFE-71DE. It was decided that the human NOEL data for trans 1,2-DCE is the most appropriate toxicity data for deriving OELs for Vertrel MCA and HFE-71DE. OELs were derived using procedures recommended by the

National Research Council. The NOEL of 800 ppm trans 1,2-DCE in air for an exposure time of 30 minutes was used as the endpoint for deriving 5, 10, 30, 60, 90, 120, 240, and 480-minute OELs for Vertrel MCA and HFE-71DE. The derived OELs for Vertrel MCA and HFE-71DE range between 48 ppm for 5 minute exposures to 0.5 ppm for 8 hour exposures.

The derived OELs for Vertrel MCA and HFE-71DE are lower than the 8-hour TLV-TWA for trans 1,2-DCE of 200 ppm, but the conservative nature of the recommended OELs reflect the lack of toxicity information for Vertrel MCA and HFE-71DE and their major ingredients. No information is available on the dermal toxicity of Vertrel MCA and HFE-71DE. Based on the toxicity information available for trans 1,2-DCE, prolonged dermal contact with Vertrel MCA or HFE-71DE should be avoided. We endorse the use of the PPE recommended by NEHC in their hazard assessment documents for Vertrel MCA and HFE-71DE when handling or using these chemicals.

If toxicity information becomes available on Vertrel MCA and HFE-71DE, NHRC/TD would be happy to look at the information and revise our recommended OELs, if appropriate.

References:

ACGIH. 2002. TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices. American Conference of Governmental Industrial Hygienists. Cincinnati, OH.

AIHA. 1999. HFE-7100. American Industrial Hygiene Association, Fairfax VA.

Bishop, M. Email: October 7, 2002, to Jim Crawl, Navy Environmental Health Center. Health Hazard Assessment for Proposed Solvents.

HSDB. Trans 1,2-DCE. File accessed 4 December, 2002. Hazardous Substances Database. National Library of Medicine. Department of Health and Human Services. United States Public Health Service.

NEHC. 2002a. Comprehensive Administrative Health Hazard Assessment: Vertrel MCA (Draft). Naval Environmental Health Center.

NEHC. 2002b. Comprehensive Administrative Health Hazard Assessment: HFE-71DE 3M™NOVEC™ Engineered Fluid (Draft). Naval Environmental Health Center.

National Toxicology Program. 2002. NTP Technical Report on the Toxicity Studies of *trans*-1,2-Dichloroethylene (CAS No. 156-60-5) Administered in Microcapsules in Feed to F344/N Rats and B6C3F1 Mice. National Toxicology Program Toxicity Report Series Report 55.

NIOSH. 1994. The Pocket Guide to Chemical Hazards. PB95-100368 National Institute for Occupational Safety and Health. Cincinnati, OH.

NRC. 2001. Standing Operating Procedures for Developing Acute Exposure Guideline Levels for Hazardous Chemicals. National Research Council. National Academy Press: Washington DC.

Sittig, M. 1985. Handbook of Toxic and Hazardous Chemicals and Carcinogens. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, p. 322.

von Oettingen, W.F. 1937. The halogenated hydrocarbons: their toxicity and potential dangers. J Ind Hyg Toxicol 19(8):409411.

von Oettingen, W.F. 1955. The halogenated hydrocarbons, toxicity and potential dangers. Washington, DC: U.S. Public Health Service Publication No. 414, p. 199.

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12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT (Maximum 200 words) <p>Currently the US Navy uses the solvent HFC-141b to clean hydraulic gauges in a semi-closed system prior to gauge calibration. The US Navy will not be able to use the solvent HFC-141b after 31 December, 2002, because of a ban on its manufacture. The Navy is considering both Vertrel MCA and HFE-71DE as replacements for HFC-141b. Both solvents are azeotropic mixtures consisting of trans 1,2-DCE and either fluorocarbons or ethers. Both Vertrel MCA and HFE-71DE have high vapor pressures, therefore, they are expected to volatilize at room temperature. The potential routes of exposure to solvent during the gauge cleaning process are inhalation of vapors and dermal contact with liquid when pouring new and spent solvents into flasks and containers. At this time, toxicity information is not available for the azeotropic mixtures Vertrel MCA and HFE-71DE. It was decided that the human NOEL data for trans 1,2-DCE is the most appropriate toxicity data for deriving OEL's for Vertrel MCA and HFE-71DE. OEL's were derived using procedures recommended by the National Research Council. The NOEL of 800 ppm trans 1,2-DCE in air for an exposure time of 30 minutes was used as the endpoint for deriving 5, 10, 30, 60, 90, 120, 240, and 480-minute OEL's for Vertrel MCA and HFE-71DE. The derived OEL's for Vertrel MCA and HFE-71DE range between 48 for 5 minute exposures to 0.5 ppm for 8 hour exposures. The derived OEL's for Vertrel MCA and HFE-71DE are lower than the 8-hour TLV-TWA for trans 1,2-DCE of 200 ppm, but the conservative nature of the recommended OEL's reflect the lack of toxicity information for Vertrel MCA and HFE-71DE and their major ingredients. Naval Health Research Center/Toxicology endorses the use of personal protective equipment when handling or using these chemicals as recommended by Naval Environmental Health Center industrial hygienists.</p>					
15. SUBJECT TERMS Vertrel MCA, HFE-71DE, solvents, pressure gauge cleaning activities, occupational exposure limit					
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